

CHAPTER I. INTRODUCTION

The Bureau of the Census, in cooperation with the Board of Governors of the Federal Reserve System, has calculated indexes of the physical volume of manufacturing production in the United States for 1947 relative to 1939. The indexes have been calculated for major industry groups and individual industries as well as for all manufacturing, and are based largely on data published in Volume II, *Statistics by Industry*, of the 1947 Census of Manufactures. The present calculations represent a continuation of the indexes for the period 1899-1939 constructed mainly from Census of Manufactures data by Solomon Fabricant of the National Bureau of Economic Research, and described in his

book, *The Output of Manufacturing Industries, 1899-1937* (New York, 1940).¹

The all-manufacturing index and the available group indexes for the whole period since 1899 are shown in table 1 and chart 1. The newly calculated 1947 indexes are shown for major industry groups and for individual industries in chapter IV and chart 2.

¹ The National Bureau indexes extended through 1939 are given in Fabricant, *Employment in Manufacturing, 1899-1939* (New York, 1942). The index for all manufacturing was reproduced in the General Summary appearing in the 1939 Census of Manufactures volumes.

TABLE 1.—INDEXES OF PHYSICAL VOLUME OF MANUFACTURING PRODUCTION FOR ALL MANUFACTURING AND FOR INDUSTRY GROUPS, CENSUS YEARS 1899-1947 ¹

[1939=100]

Year	All manufacturing industries	20—Food	21—Tobacco	22 and 23—Textiles and apparel	24 and 25—Lumber and furniture	26—Paper	27—Printing	28—Chemicals	29—Petroleum and coal products
1947.....	174	154	150	125	138	147	144	216	154
1939.....	100	100	100	100	100	100	100	100	100
1937.....	101	93	97	89	96	93	105	93	94
1935.....	81	80	84	83	74	78	90	76	76
1933.....	61	57	73	72	58	64	75	63	64
1931.....	70	64	77	73	80	66	87	66	69
1929.....	98	71	83	84	125	70	103	75	83
1927.....	85	65	74	79	125	68	85	62	89
1925.....	80	62	68	72	129	59	85	52	82
1923.....	75	59	61	69	114	53	76	49	53
1921.....	52	48	55	54	105	38	54	32	34
1919.....	60	49	58	57	99	40	56	30	32
1914.....	50	52	44	60	103	35	49	32	18
1909.....	42	44	36	51	104	28	37	24	13
1904.....	33	37	31	40	96	20	27	17	8
1899.....	27	30	25	32	103	14	18	14	7

Year	30—Rubber products	31—Leather	32—Stone, clay, and glass products	33—Primary metals	34—Fabricated metal products	35—Machinery (except electrical)	36—Electrical machinery	37—Transportation equipment	38 and 39—Instruments and miscellaneous
1947.....	182	115	170	192	198	267	286	202	193
1939.....	100	100	100	100	100	100	100	100	100
1937.....	93	98	102	111	101	n. a.	n. a.	122	n. a.
1935.....	82	90	70	75	n. a.	n. a.	n. a.	97	n. a.
1933.....	71	78	48	52	n. a.	n. a.	n. a.	45	n. a.
1931.....	72	73	69	62	n. a.	n. a.	n. a.	61	n. a.
1929.....	103	91	102	124	n. a.	n. a.	n. a.	134	n. a.
1927.....	95	88	101	100	n. a.	n. a.	n. a.	91	n. a.
1925.....	87	77	93	101	n. a.	n. a.	n. a.	102	n. a.
1923.....	74	86	n. a.	101	n. a.	n. a.	n. a.	101	n. a.
1921.....	44	68	n. a.	49	n. a.	n. a.	n. a.	51	n. a.
1919.....	55	82	n. a.	77	n. a.	n. a.	n. a.	82	n. a.
1914.....	n. a.	73	n. a.	55	n. a.	n. a.	n. a.	27	n. a.
1909.....	n. a.	75	n. a.	54	n. a.	n. a.	n. a.	14	n. a.
1904.....	n. a.	67	n. a.	35	n. a.	n. a.	n. a.	10	n. a.
1899.....	n. a.	58	n. a.	27	n. a.	n. a.	n. a.	10	n. a.

n. a. Not available.

¹ The 1947 indexes are those here calculated, employing cross weights and including adjustments for missing industries. See ch. IV. The indexes for 1899-1939 are those calculated from Census of Manufactures data by Solomon Fabricant of the National Bureau of Economic Research, converted to a 1939 base. The indexes for 1947 and those for earlier years differ in the methods used for adjusting for missing industries. In constructing the 1947 indexes, similarity of output per employee was assumed for included and missing industries of each group, whereas for 1899-1937, similarity of value added per unit of output was assumed. See ch. II, "Adjustments for missing industries," and table 7.

Because of changes in census industry-group classifications, the following combinations and recomputations were required: The 1947 indexes for the "Textiles and apparel" and for the "Lumber and furniture groups," respectively, were combined to approximately correspond with the industry group classifications used in the National Bureau indexes for 1899-1937. The National Bureau "Foods" and "Beverages" indexes were combined to yield 1899-1937 indexes for the "Food" group as defined for 1947. The 1899-1937 series for "Primary metals" was constructed by National Bureau methods from National Bureau series for 5 to 13 industries classified in this group for 1947; in each year they represented over 75 percent of the value added for the group. Similarly, the 1937 index for "Fabricated metal products" was constructed from 14 National Bureau series representing 46 and 47 percent, respectively, of the value added for the group in 1937 and 1939.

In addition to a presentation of the results, this report includes a discussion of the objectives of the study, the problems encountered, and the methods employed. These all are generally similar to those described in Fabricant's work, on which the present discussion leans heavily at many points, and to which readers are referred for a more exhaustive treatment of a number of topics. Certain departures from Fabricant's methods are noted in the discussion.

Reasons for the Census Indexes

The development of information on the physical output of manufactured commodities has always been regarded as a principal purpose of the Census of Manufactures. For 1947, such statistics are shown in the basic census volumes for about 4,800 commodities, substantially more than in previous years. In addition to the data in physical units, various types of output statistics in dollar terms are also shown. These include values for the 4,800 commodities for which quantity figures are given and for the remaining products or classes of products; value of output of most individual industries; and value added by manufacture in individual industries, industry groups, and all manufacturing. Comparable data are given in the 1947 volumes for 1939, the year of the last previous census, wherever they are available.

The census provides the most nearly complete record of United States manufacturing production available from any source. In addition to the production figures described, related information is also shown on cost of materials, input of labor and fuels, capital expenditures, and inventories.

The physical output figures of the census relate to individual products, and must be combined if summary measures of physical volume changes from 1939 to 1947 are to be obtained. These cannot be calculated directly by comparing the statistics on value of products or value added for the 2 years because they are affected by price as well as quantity changes. The present indexes provide such summaries of physical volume changes. In this sense they may be regarded as supplements to other aggregate census statistics.

The first major reason for making these manufacturing production indexes, then, is to supplement the data given in the census volumes with aggregate measures of change in output that are free from price changes. Such measures make possible comparisons of physical output changes among industries or groups of industries, between all manufacturing industries and agriculture, mining, and any other broad segments of the economy for which output data are available, and between manufacturing output in the more recent period and the record of the past.

A second major reason for making these indexes is to provide bench marks for current production indexes. Since the Census of Manufactures data are generally more comprehensive than those available monthly or annually from other sources, they provide the basis for more accurate estimates of output change than can be developed from other data. Current monthly indexes, such as the manufactures component of the index of industrial production published by the Federal Reserve Board, can be improved by adjusting their levels to bench-mark indexes based on census data. The Federal Reserve Board plans to use the results in this way. The need for bench-mark indexes to check and correct the longer-term levels of current measures is emphasized by the Statistical Office of the United Nations in its recently published *Studies in Methods No. 1, Index Numbers of Industrial Production* (New York, 1950).

Before the present study and the one by Fabricant mentioned earlier, several other indexes of manufacturing output had been constructed from Census of Manufactures data. These include the Day-Thomas index, which was issued as a Census monograph,² and an index constructed by Frederick C. Mills of the National

Bureau of Economic Research.³ This study, however, is the first in which the regular working staff of the Census Bureau has participated. There are distinct advantages in having the indexes constructed by the people who originally compiled the underlying data. The Bureau's commodity specialists are familiar with the merits and limitations of the statistics for individual products and industries; they have ready access to extensive correspondence files, special analytical tables, machine tabulation listings, and reports of individual manufacturers; and they also can use disclosure items in constructing the indexes. As is well known, the Bureau of the Census is prohibited by law from publishing statistics that approximately disclose the operations of individual companies. When, however, such statistics are combined with other disclosure items in constructing indexes, the disclosure is avoided. Persons outside the Bureau obviously cannot avail themselves of such data.

There also has been an incidental advantage in the other direction. Work on the indexes has served to point up to the Bureau's staff the areas in which census quantity figures are inadequate with regard to completeness and homogeneity of product classifications, and in which the quantity and other figures suffer from lack of comparability between one census year and another.

There are two important qualifications to be attached to the indexes. First, while the specific definition given to "physical volume of production" is equivalent to that used in most indexes so described, it is but one of a number theoretically possible, and may not be the best for a particular purpose. Secondly, a substantial amount of estimating and some important assumptions were necessary because of limitations in the basic data, and the results should be considered as approximate. However, they probably are more reliable than those of previous studies of this sort for the United States, mainly because of the improvements in the published statistics that have occurred and the availability, for this study, of unpublished census data.

Scope of the Indexes

The indexes relate only to manufacturing establishments, as covered in the Census of Manufactures. Thus, they represent a narrower area than "industrial" production, which as defined at present in the Federal Reserve index includes mining also, and, in a number of foreign indexes, construction and certain public utilities as well. They do not cover nonindustrial areas of the economy such as trade, services, and agriculture, and therefore do not represent "total" economic output.

The definition and classifications of manufacturing establishments used are those given in the Standard Industrial Classification Manual, volume I,⁴ with certain modifications in the classifications made in the 1947 census and a few additional modifications found necessary for the indexes and described in a later section.

Definition of Physical Volume

It was noted earlier that the purpose of the present study is to construct "physical volume" indexes—that is, aggregate measures of output change that are free from the influence of price changes. The change in "physical volume" is specifically defined as the change in value of net output, or value added, at constant prices. This definition is used in most national production indexes except those calculated for special purposes, and is the one recommended in the United Nations study mentioned earlier.

Broadly speaking, the net output of an industry in a particular period is the difference between the value of its products—its "gross" output—and the contributions to this value made by other industries in the form of raw materials, fuels, etc., supplied by them and consumed in manufacture. This difference represents the value that is "added" to raw materials, etc., within the given industry, in transforming them into finished products (which then frequently serve as materials for the next industry). For

² E. E. Day and W. Thomas, *The Growth of Manufactures, 1899-1928* (Washington: 1928). The indexes were later extended through 1937 by various researchers.

³ F. C. Mills, *Economic Tendencies in the United States* (New York, 1932).

⁴ Executive Office of the President, Bureau of the Budget (Washington, 1946).

census purposes value added is calculated by subtracting from the value of products the costs of "inputs" of materials, supplies, containers, fuels, purchased electric energy, and contract work.⁵

Symbolically, the value added in an industry in, say, 1947, can be written as follows, with q representing the quantities of each of the various products made, p their respective unit values, Q the quantities of each of the materials, etc., consumed, and P their respective unit costs:

$$(1) \quad VA_{1947} = \sum q_{47} p_{47} - \sum Q_{47} P_{47}$$

The change in value added from 1939 to 1947 is measured by the ratio:

$$(2) \quad VA \text{ ratio} = \frac{\sum q_{47} p_{47} - \sum Q_{47} P_{47}}{\sum q_{39} p_{39} - \sum Q_{39} P_{39}}$$

Such calculations of value added ratios can be made from the published census statistics, but it is clear that they reflect price as well as quantity changes. "Constant" prices are, therefore, introduced; the price terms for 1947 and 1939, which ordinarily would differ for equivalent products (and materials), are replaced by the constant prices, p_c and P_c . These are taken from some chosen "weight period," which may be one year or the other, an average for the two, or some other period. They are applied to quantities of individual products and materials in both years, as in the following index:

$$(3) \quad I_{net} = \frac{\sum q_{47} p_c - \sum Q_{47} P_c}{\sum q_{39} p_c - \sum Q_{39} P_c}$$

The definition of "physical volume" as net output at constant prices, as formulated in (3), is but one of a number of possible definitions leading to measures which are useful for different purposes. One alternative measure would reflect the change in gross output, or value of products, of an industry at constant prices. This would differ from (3) in that the right-hand terms of both numerator and denominator, representing materials, etc., consumed, would be omitted, as in (4):

$$(4) \quad I_{gross} = \frac{\sum q_{47} p_c}{\sum q_{39} p_c}$$

The gross output measure reflects the flow of goods out of the industry, and would be preferred for problems centering around the availability of the industry's products. The net measure would be preferred for problems concerning the industry itself, where it is desired to separate the industry's contribution from those of industries at earlier stages in the production process.

The choice between net and gross measures for a particular industry thus depends on the purpose at hand. For an index in which all manufacturing industries are to be combined, however, the preference is clearly in favor of the net figures. This is because the use of the products of some industries as materials by others leads to a tremendous amount of duplication in aggregated value statistics. Totals with large amounts of duplication not only are of obscure meaning but can be misleading. It was for this reason that publication of value of products statistics was discontinued in the 1947 Census of Manufactures for aggregates larger than individual industries, and also for 12 individual industries where there was substantial internal duplication. For the same reason the constant price measure of value added, rather than of value, was the objective of the present study.

⁵ The United Nations report recommends that, for making production indexes, census value added be adjusted (on the basis of supplementary inquiries) by also subtracting the costs of purchased business services such as advertising and insurance, and certain other items, but this was not found feasible. If these subtractions had been made from value added, and if depreciation costs had also been subtracted, the remainder would approximate "national income originating in manufacturing" as defined by the Department of Commerce.

It will be seen later that limitations imposed by the available data required the use of estimates of the change in value added at constant prices for individual industries rather than exact calculations under formula (3), and that these estimates consist essentially of the change in value at constant prices indicated by formula (4). The industry indexes, therefore, err as approximations to the desired indexes insofar as the changes in gross output of individual industries differ from changes in net output. These individual industry indexes, however, are combined into group and total indexes with "weights" representing their relative importance in terms of value added, rather than value.⁶

The use of value added weights for combining industry indexes yields approximations of the desired aggregate net measures—approximations which will be good if gross and net output changes within industries are similar, or the differences which exist between gross and net output changes offset among the industries included in a particular aggregate. This will be discussed further in chapter II.

Both the net and gross output indexes described are "dollar" measures, in that the relative importance assigned to the various commodities and industries depends on market prices in some period (the period from which the constant prices are drawn). Such measures probably have the broadest general usefulness. For special purposes, however, nonpecuniary indexes of physical volume may be preferred. A measure of the change in the total tonnage of output, for instance, may be desired in connection with transportation problems. For this purpose, prices would be irrelevant; the importance attached to the various types of goods—that is, the weights used in the index—should be proportional to their respective tonnages.

Another type of measure is obtained by weighting quantities of output in each period by the requirements per unit of product of some type of input, such as labor, in a particular period. Such a procedure is followed by the Bureau of Labor Statistics in making productivity studies. The index derived in this manner measures the changes in total labor requirements that would have resulted from changes in output of the various products if unit labor requirements for each of the products had remained constant. When this index is divided into an index of the change in actual amounts of labor employed, the ratio reflects the change that has occurred in unit labor requirements.⁷

The use of different systems of weighting may or may not lead to important differences in measures for particular time periods. In the present instance few important differences would result if the value added weights used for combining industry indexes into group and all-manufacturing indexes were replaced with labor input weights, proportional to the number of employees in the various industries.

The results of such a calculation are shown in table 2. The difference for the all-manufacturing indexes is only one point or about one-half of 1 percent, and for most major groups they are four points or less. The greatest difference occurs in the tobacco products group, where labor input is relatively less important in the highly mechanized cigarette industry than in the other tobacco industries. While the differences in general are small, it should be noted that larger differences might have been found if labor input weights were substituted for value weights in making the individual industry indexes as well as in combining them into group and total indexes, and also that larger differences might be found with regard to other weighting systems or other time periods.

⁶ If value weights had been used, the aggregate indexes would in fact have reflected the changes in value at constant prices, with all of the interindustry duplication involved in such measures.

⁷ The results are equivalent to those obtained by appropriately averaging the changes in unit labor requirements for each product.

INDEXES OF PRODUCTION

TABLE 2.—DIFFERENCES IN 1947 INDUSTRY-GROUP INDEXES RESULTING FROM USE OF VALUE ADDED AND EMPLOYMENT WEIGHTS

[1939=100]

No.	Industry group	Group indexes derived by combining industry indexes with 1939		Difference	
		Value added weights	Employment weights	Absolute (column 2-column 1)	Percent (column 3-column 1)
	Title	(1)	(2)	(3)	(4)
	All manufacturing industries.....	178	177	-1	-0.6
20	Food and kindred products.....	150	146	-4	-2.7
21	Tobacco manufactures.....	155	134	-21	-13.5
22	Textile mill products.....	131	128	-3	-2.3
23	Apparel and related products.....	119	118	-1	-0.8
24	Lumber and products, except furniture.....	126	125	-1	-0.8
25	Furniture and fixtures.....	(1)	(1)	(1)	(1)
26	Paper and allied products.....	150	149	-1	-0.7
27	Printing and publishing industries.....	144	144	0	0
28	Chemicals and allied products.....	228	232	+4	+1.8
29	Petroleum and coal products.....	158	158	0	0
30	Rubber products.....	186	187	+1	+0.5
31	Leather and leather products.....	114	113	-1	-0.9
32	Stone, clay, and glass products.....	175	168	-7	-4.0
33	Primary metal industries.....	184	186	+2	+1.1
34	Fabricated metal products.....	200	198	-2	-1.0
35	Machinery (except electrical).....	272	270	-2	-0.7
36	Electrical machinery.....	277	277	0	0
37	Transportation equipment.....	199	202	+3	+1.5
38	Instruments and related products.....	177	169	-8	-4.5
39	Miscellaneous manufactures.....	177	169	-8	-4.5

¹ Figures for group 25 are included with those for groups 38 and 39. See ch. II, "Adjustments for missing industries."

NOTE.—Group indexes employ 1939 weights and are without adjustments for missing industries. See ch. II, "Adjustments for missing industries."

Importance of the Weight Year

The desire to construct a measure of output that is free from the influence of price changes leads to the use of the same set of prices for valuing the goods of both years. However, the change in output found may depend in part on the weight period selected—that is, on the particular set of prices used as "constant." This is because relative prices change from one year to another, and the various commodities and industries are given different weights under the different sets of prices.

Among the alternative weight periods are the "base" year, which is 1939 in this case (Laspeyres' formula) and the "given" year, 1947 (Paasche's formula). The commodities that had lower prices relative to others in 1947 than in 1939 are given less importance in Paasche's formula than in Laspeyres'. In the present instance, these commodities tended to be those whose output rose most; the lesser importance given them under the 1947 system of prices results in a lower index for 1947 (relative to 1939) than that obtained by using 1939 prices.

A procedure frequently followed is to calculate indexes with both base year and given year prices and average the two indexes, or, to average the prices before applying them to the quantities in both years. Both of these methods, which are known respec-

tively as Fisher's "ideal index" formula (if the average used is the geometric mean) and the Marshall-Edgeworth, or cross-weighted, formula, give results intermediate to the two obtained by the use of base and given year prices. The Marshall-Edgeworth formula was used in the present study, as it was in Fabricant's work. However, because the single measure obtained by averaging the prices gives no information on the range of difference averaged out, which may vary from negligible to substantial, it was considered desirable in the present study also to calculate indexes using the prices of each of the 2 years alone.

TABLE 3.—COMPARISON OF 1947 INDUSTRY-GROUP PRODUCTION INDEXES WITH DIFFERENT WEIGHT BASES

[1939=100]

No.	Industry group	Indexes based on—		
		Cross weights	1947 weights	1939 weights
	Title			
	All manufacturing industries.....	174	169	184
20	Food and kindred products.....	154	151	159
21	Tobacco manufactures.....	150	146	155
22	Textile mill products.....	128	127	131
23	Apparel and related products.....	121	121	122
24	Lumber and products, except furniture.....	127	127	127
25	Furniture and fixtures.....	(1)	(1)	(1)
26	Paper and allied products.....	147	146	150
27	Printing and publishing industries.....	144	145	144
28	Chemicals and allied products.....	216	200	241
29	Petroleum and coal products.....	154	153	156
30	Rubber products.....	182	179	186
31	Leather and leather products.....	115	115	115
32	Stone, clay, and glass products.....	170	167	176
33	Primary metal industries.....	192	191	192
34	Fabricated metal products.....	198	196	201
35	Machinery (except electrical).....	267	260	277
36	Electrical machinery.....	286	290	280
37	Transportation equipment.....	202	200	207
38	Instruments and related products.....	183	178	193
39	Miscellaneous manufactures.....	183	178	193

¹ Figures for group 25 are included with those for groups 38 and 39. See ch. II, "Adjustments for missing industries."

NOTE.—Indexes include adjustments for "missing" industries in each group. See ch. II, "Adjustments for missing industries."

Indexes with the three sets of valuations are shown in table 3 for all manufacturing and for major industry groups, and in chapter IV for individual industries. The all-manufacturing index for 1947 with 1939 weights is 15 points, or about 9 percent, higher than that with 1947 weights. The 1939-weighted indexes for 14 of the 18 industry groups also are higher than the 1947-weighted indexes, with differences ranging up to 20 percent in the case of chemicals. For individual industries the 1939-weighted indexes are higher in 103 cases and the 1947-weighted indexes are higher in 38 cases. It is of interest to note that for a roughly similar period (1938-46) in Great Britain, according to calculations made at the Central Statistical Office,⁸ an index of manufacturing output with prewar weights was 5 percent higher than one using postwar weights.

⁸ Central Statistical Office, *The Interim Index of Industrial Production* (London, 1949).

Chart
2

INDEXES OF PRODUCTION FOR MANUFACTURING INDUSTRY GROUPS AND INDUSTRIES: 1947

1939 = 100

